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TI Brazing filler for copper and its alloys
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AB Shrinkage porosity in the joints is decreased, and the strength is increased when the braze alloy contains In 0.5-1.5 and Si 1.0-4.5% in addition to Ni 8-15, Sn 5-12, P 5-10%, and Cu as the balance.

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SOLDER FOR SOLDERING COPPER AND ALLOYS THEREOF
[PRIPOY DLYA PAYKI MEDI I YEYO SPLAVOV]

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The invention concerns machine construction, in particular for soldering metal articles made of copper and alloys thereof, German silver, nickel, molybdenum, and also ceramics and metal ceramics, using homogenous plastic strip or powdered copper-based solders as the solder.

These solders are intended to provide strength and corrosion resistance of the solder joint, a lower soldering temperature, and self-fluxing. In addition, one of the basic requirements is absence of porosity in the solder seam, which is necessary for soldering certain important articles, for example parts intended for connecting radio measuring apparatus. The presence of porosity in solder joints leads to a reduction of the annual production output.

Silver-containing solders of the PSr45 and PSr72 type, known from All-Union State Standard 19738-74 and having 39-72% by weight of silver in their composition, are known. The solders are used for soldering parts made of copper and its alloys, in particular brass parts. They have high strength and corrosion resistance in the joint, a relatively low soldering temperature, the metals soften well and flow into gaps. They provide the following properties, shown in Table 1.

*Numbers in the margin indicate pagination in the foreign text.

The scarcity and high cost of silver, the expensive technology of producing solders, and also the porosity of the area of the solder seam are disadvantages of these solders.

The solder PMFS6-0.15 for soldering parts made of copper and alloys thereof is known.

The solders have the composition and properties shown in Table 2.

Solder is characterized by the complex technology of producing /2 it and using it for soldering. Porosity also is detected in a joint made with the above-mentioned solder, although the amount of porosity is 10% lower than in the case of using silver solders. In addition, the residues of the flux used in soldering cause corrosion of the seam, reducing the strength characteristics.

Copper-based alloys are known.

The solder has the composition given in Table 3.

The solder of the most common composition contains, in % by weight:

nickel	9.91
tin	4.00
phosphorous	7.84
copper	78.25

The basic characteristics of the solder are the following:

temperature - solidus, °C	610
temperature - liquidus, °C	730-780

tensile strength, MPa	208
seam porosity, %	10-15

The solder has satisfactory temperature and strength characteristics, is self-fluxing, and may be used instead of silver-containing solders for soldering copper and alloys thereof.

A disadvantage of this solder is the porosity of the solder seam due to the long solid-liquid hardening time at the time of making a joint. The pore concentration in fillet sections of the seam is especially high. In this case the porosity of the joint, sealing, and vacuum density are decreased, which reduces the area of its application.

The purpose of the invention is to reduce the shrinkage porosity of the soldered seam and to strengthen the solder joint.

In order to achieve the indicated goal in a solder containing copper, nickel, tin, and phosphorous, silicon and indium are additionally introduced with the following ratio of components, in % by weight:

nickel	8.0-15.0
tin	5.0-12.0
phosphorous	5.0-10.0
indium	0.5-1.5
silicon	1.0-4.5
copper	remainder

the total indium and silicon content being 1.5-5.5 % by weight.

Reduction of the shrinkage porosity and strengthening of the solder joint are achieved by alloying the solder with silicon and indium within the indicated limits.

The porosity of the solder seam was studied on microsections, the concentration of shrinkage pores was evaluated by radiographic monitoring in flat and fillet sections of the seam.

The solder alloy is melted in an argon atmosphere in an induction furnace. The components, namely copper, nickel, tin, silicon, and copper phosphide are put into a crucible. The crucible is put into a furnace, heated to 1080-1090°C until complete melting of all components, the temperature of the melt is gradually reduced to 750-800°C, and the indium is introduced. After complete dissolution of the indium the melt is cooled.

The proposed solder is prepared in the form of a film, or strip and powder. A strip 0.02-0.06 mm thick is obtained by rapid cooling of the melt by means of putting it onto a cooled metal disk, revolving at a speed of 20-40 m/s.

Powder is obtained by centrifugal dispersion of the melt on a disk. Both processes provide for the presence of an amorphous or microcrystalline phase in the structure.

A solder of a known alloy is produced in parallel. The solder is produced in the form of a strip 10-40 mm wide and 0.02-0.06 mm thick.

Solder samples are prepared in accordance with All -Union State Standard 23047-78 for expansion tests. Sheet copper is used as the

basic material and L63, LS59 brass 1.5 mm thick is used as the welding strip. The samples are soldered overlapped, the amount of overlapping being 3 mm. Before soldering the samples are degreased with acetone and washed with alcohol, and are subjected to chemical pickling. Boric acid or F209 flux are used as the flux. The solder is placed so that it completely covers the entire area of overlapping. Then the samples are fastened and soldered with a torch with a reducing flame, after which they are cooled to room temperature and the flux residues are removed mechanically.

The characteristics of joints soldered with strip solders of known and proposed components at the lower, middle, and upper limits, and also exceeding the lower and upper limits are given in the table.

The results of the tests of the joints soldered with the proposed solder demonstrated their advantage in comparison with the known solder. The best combinations of solder properties are obtained in the case of the addition of silicon in an amount of 1.0-4.5, indium 0.5-1.5% by weight, the total silicon and indium content being in an amount of 1.5-5.5 % by weight. In this case the soldering temperature is lowered, the strength of the joint is increased, /3 and a practically complete absence of shrinkage porosity due to the shortening of the solid-liquid state period at the time of hardening is observed. In addition, the solders do not corrode during long-term storage.

When silicon and indium are introduced in amounts below the lower limit into the composition of the alloy, the hardening time increases and formation of shrinkage porosity becomes possible; in the case of introducing the indicated additives above the overall upper limit the solder seam becomes brittle.

The advantage of the solder is that it can be used without complex fluxes. Powdered solder of this composition does not need additional preparation.

The technical-economic advantages of using the proposed solder consist in the possibility of using the former for producing a reliable inexpensive solder joint.

The cost of a joint soldered with silver solder is 15 rubles, the cost of a joint soldered with the proposed solder is 3 rubles. The economic effect per 1 thousand parts

$$E = (15-3) \cdot 10^3 = 12,000 \text{ rubles.}$$

The technical advantages of using the solder are that the solder joint has great strength, and the solder seam does not have pores, which expands the area of its application in technology.

Formulation of the Invention

A solder for soldering copper and alloys thereof, containing nickel, tin, and phosphorous, wherein, in order to reduce the shrinkage porosity of the solder seam and strengthen the solder joint, the solder additionally contains silicon and indium with the following ratio of components, in % by weight:

nickel	8-15
tin	5-12
phosphorous	5-10
indium	0.5-1.5
silicon	1.0-4.5
copper	remainder

Table 1

solder brand	content in composition, % by weight			temperature, °C		tensile strength, MPa	porosity, %
	Ag	Cu	Zn [sic]	liquid solder			
PSr45	44.5-45.0	29.5-30.4	remainder	610	680-780	144	15
PSr72	71.5-72.5	remainder	-	779	808-850	185	20

Table 2

solder brand	content in composition, % by weight				temperature, °C		tensile strength, MPa	porosity, %
	Cu	Ag	P	Si	liquid solder			
PMFS6-0.15	remainder	3	5-6	0.15	710	750-780	140-149	5-10

Table 3

Ni	Sn	P	Cu
6.5-48.24	4.0-18.5	4.8-7.8	remainder

Table 4

Пробирка	Средние значения, мас. %							Температура, °C		Прочность, кг/см²		Удлинение, %	
								сжатия	растяжения	по длине	по ширине	по длине	по ширине
	Fe	Si	P	Cu	Sn	Al	Si-Mn						
3 Измельченный	8.37	4.0	7.80	78.25	-	-	-	810	800	208	10	15	-
2 Предварительный	8.6	5.91	5.00	80.49	1.0	0.5	1.5	805	877	221.4	-	-	-
3	8.0	5.00	5.00	78.70	3.2	1.10	3.30	843	873	223.3	-	-	-
4	8.0	5.00	5.00	78.68	4.0	1.5	5.0	802	889	223.1	-	-	-
5	8.0	5.00	5.00	75.5	4.5	1.0	5.5	830	873	215	-	-	-
6	12.0	8.00	7.5	71.0	1.0	0.5	1.5	882	878	224	-	-	-
7	12.4	8.00	7.5	68.64	2.21	1.05	3.26	831	872	229.3	-	-	-
8	12.0	8.5	7.5	66.5	4.5	1.0	5.5	800	878	218.5	-	-	-
9	12.0	8.5	7.5	68.9	4.0	1.0	5.5	800	871	212	-	-	-
10	15.0	12.0	10.0	61.5	1.0	0.5	1.5	850	888	211	-	-	-
11	15.0	12.0	10.0	59.79	2.21	1.0	3.20	806	875	210	-	-	-
12	15.0	12.0	10.0	67.5	4.5	1.0	5.5	802	870	218	-	-	-
13	15.0	12.0	10.0	57.5	4.5	1.5	5.5	805	874	210	-	-	-
14 Выходной													
38 Пробирка со													
досками	8.0	5.0	5.0	78.41	4.00	1.5	5.50	823	888	185	4	7	7
15	8.0	5.01	5.0	76.79	4.5	1.1	5.5	829	889	179	3	6	6
16	9.0	8.5	7.5	73.50	0.88	0.04	1.41	811	888	200	7	17	17
17	10.0	8.0	7.5	68.50	4.5	1.5	8.0	800	878	174	8	13	13
18	7.5	4.5	4.5	81.80	0.90	0.4	1.34	883	750	183	10	14	14
19	7.8	4.7	4.5	79.80	2.1	1.1	3.2	871	711	150	5	9	9
20	15.5	12.7	11.0	57.60	0.1	0.0	3.2	871	887	183	7	13	13
21	15.5	12.5	10.5	55.27	4.5	1.03	5.73	830	883	147	15	23	23

Remark: Soldering tests were performed on L63 samples.

Key:

solder	component content % by weight							temperature, °C		tensile strength of seam, MPa	shrinkage porosity of solder seam	
								solidus	liquidus		flat	fillet
1 known 2 proposed												
14 composition exceeding limits												